The Lakes of Maple Valley and Covington

A Report on Monitoring Results for the 2013 Water Year at Lake Lucerne, Pipe Lake, and Lake Wilderness

Lake Wilderness, July 2007 photo by Sally Abella, King County Lakes Program

February 16, 2014

King County

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A Report on Monitoring Results for the 2013 Water Year at Lake Lucerne, Pipe Lake, and Lake Wilderness

Prepared for:

The Cities of Maple Valley and Covington.

Submitted by:

Lakes and Streams Monitoring Group
Science and Technical Support Section
King County Water and Land Resources Division
Department of Natural Resources and Parks

King County

The City of MAPLE VALLEY

City of Covington

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Overview

The King County Lakes and Streams Monitoring Group and its predecessor the Lake Stewardship Program have worked with volunteers to monitor water quality for three lakes that are currently within the Cities of Maple Valley and Covington. Lake Lucerne data has been collected since the 1980s, while Pipe and Wilderness Lakes have been monitored since the 1970s. The water quality data indicate that the three lakes currently range from low to moderate in primary productivity, with generally good water quality.

The discussion in this report focuses on the 2013 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake small lakes data website at: http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Data can also be provided in the form of excel files upon request.

Further introduction and a discussion of the philosophy of the volunteer lake monitoring program and the parameters measured can be found on-line at:

http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/2006_Intro.pdf

What We Measure and Why

Measurements that were taken at all of the lakes in the small lakes monitoring program are discussed in this section to introduce the parameters and give context to the discussions of the data that follow.

Lake level is a relative measure of the water level that is measured daily using a staff plate installed on either a pole or a fixed height dock . These data can be used to look at the annual fluctuation of water levels in the lake, as well as response to increased water coming in due to storm events and the rate at which it drains. While most of the installed staff plates at lakes around the county are not surveyed to tie the data in with sea level, this could be done in the future to give actual elevations.

Daily **precipitation** is measured at the same time as lake water level in order to relate the lake level to inputs from the watershed. These data are collected either through a plastic rain gage provided by King County that can be emptied after reading each day or by a recording weather station if the volunteer chooses to purchase a reliable unit.

Level I volunteers measure Secchi depth and water temperature at a station in the middle of the lake weekly throughout the year. Level II volunteers measure 12 times between May and October when they collect water samples for laboratory analysis.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface. Factors in the water that affect Secchi readings include the number and size of particles present, such as algae and silt, as well as water color from dissolved organic molecules. Other factors that affect the readings are the amount of glare, choppiness of the water, shade from tall trees or the boat, and variation in the vision of the observers.

Water temperature is usually measured using an alcohol-based thermometer that holds a specific temperature long enough to allow the observer to read the value after retrieving the thermometer from the water.

Phosphorus and nitrogen are naturally occurring elements necessary for growth and reproduction in both plants and animals. However, many activities associated with residential development can increase these nutrients in water beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is most often limited by the amount of available phosphorus. Increases in phosphorus can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by cyanobacteria (bluegreen algae) that can produce toxins.

Total phosphorus (TP) and **total nitrogen (TN)** are both measured every time the level II volunteers collect water at the 1m depth. More specific forms of nitrogen and phosphorus are measured twice during the sampling period, when water is collected from 3 depths at the station: 1 m, the middle depth of the water column, and 1 m from the lake bottom. These include nitrate-nitrite, ammonia, and soluble reactive phosphorus, and the data can be used to infer the amount of oxygen present in deep water, as well as the presence of internal loading of nutrients from the sediments back into the lake water.

The **ratio of total nitrogen to total phosphorus (N:P)** can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria (bluegreen algae), which can negatively impact uses of the lake and potentially produce toxins. When N:P ratios are near or below 25, nitrogen is as likely to be the limiting nutrient as phosphorus. Cyanobacteria may then be able to dominate the algal community due to their ability to take up nitrogen from air.

Chlorophyll-*a* concentrations indicate the abundance of phytoplankton in the lake. Although different species of algae contain varying amounts of chlorophyll, all algae use it in order to complete the photosynthetic pathway by which they store energy. For example, some cyanobacteria have other light-catching pigments and thus have relatively little chlorophyll compared to their biovolume.

Pheophytin is a product of chlorophyll decomposition and is generally measured along with chlorophyll as an indicator of how fresh or viable the phytoplankton in the sample are. Bottom sediments will contain a large amounts of pheophytin compared to chlorophyll, while actively-growing algae from surface waters will have very little pheophytin present.

A common method of tracking water quality trends in lakes is by calculating the **Trophic State Index (TSI)**, developed and first presented by Robert Carlson in a scientific paper dated 1977. TSI values predict the biological productivity of the lake based on three parameters that are easily measured: water clarity (Secchi), total phosphorus, and chlorophyll-*a.* The values are scaled from 0 to 100, which allow them to be used for comparisons of water quality over time and between lakes. If all of the operating assumptions about a lake ecosystem are met, the 3 TSI values should be very close together for a particular lake. When they are far apart in value, lake conditions and measurements should be examined to understand what special conditions exist at the lake or to evaluate the data for errors.

The Index relates to three commonly used categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

A lake may fall into any of these categories naturally, depending on the conditions in the watershed, climate characteristics, vegetation, and rock and soil types, as well as the shape and volume characteristics of the lake basin. Activities of people, such as land development, sanitary waste systems, and agricultural practices, can also increase productivity, which is known as “cultural eutrophication.”

1.0. LAKE LUCERNE

While a small number of samples were taken in the 1970s, consistent volunteer monitoring began at Lake Lucerne in the 1980s and continued through 2013, with only one gap in the early 1990s. The data indicate that this 16-acre lake is relatively low in primary productivity (oligotrophic - mesotrophic) with good to excellent water quality.

Lake Lucerne has no public access boat launch, but does have a history of both milfoil and hydrilla infestations for which eradication efforts have been underway since 1995. Milfoil has been eradicated, and the last hydrilla plant was found seven years ago. Lake Lucerne has not been treated with the herbicide fluridone (Sonar PR ™) since 2008. The year 2013 was the fourth year since the last treatment in adjoining Pipe Lake. King County and its contractor will continue to monitor one further year for resurgence of Hydrilla or Eurasian watermilfoil. Recently, a healthy mixture of native *Potamogeton* species has recolonized the bottom of both lakes. Lake users and residents should keep a close eye on aquatic plants growing nearshore to catch new or expanding patches of noxious weeds, but encourage native species that provide good habitat for fish and other aquatic animals.

1.1 Physical Parameters

No precipitation or lake level data were collected for Lake Lucerne in 2013.

Volunteers collected Secchi depth transparency and 1m temperature data from early May through late October during the “Level 2” monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency ranged between 3.0 and 6.2 meters (m) from May through October (Figure 1), averaging 5.1 m, which is fairly typical clarity for Lake Lucerne. The volunteer monitor noted that the lake surface was very choppy during the Secchi evaluation in late July, which could easily have lowered the reading. All other values were between 4.5 and 6 meters in depth.

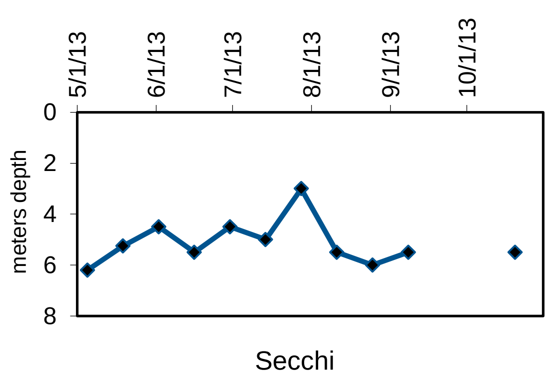

Figure 1. WY 2013 Lake Lucerne Secchi Depth. Note inverted Y-axis.

Surface water temperatures reached a maximum of 26.5 degrees Celsius, with an average of 21.8 degrees (Figure 2) over the period, which was second only to Pipe Lake as the warmest of the monitored lakes in 2013. A large jump in temperature during June was followed by a small decrease over time until September, when the lake began cooling more rapidly.

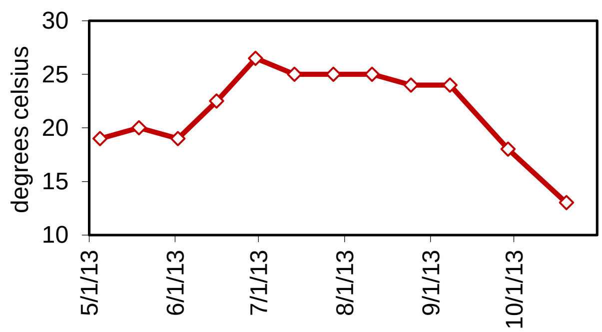

Figure 2. WY 2013 Lake Lucerne Temperature

Mean summer water temperatures over the years that Lake Lucerne has been monitored have varied (Figure 3), but to-date there is no statistically strong trend toward a directional change through time. The correlation coefficient of a trend line fitted to the values is small and does not support a trend over time. Trend analysis was particularly affected by the warm years of 2009, 2012, and 2013, when seasonal averages were higher than in other years in the series.

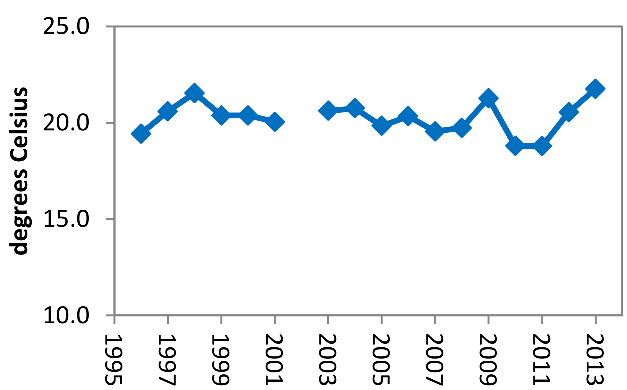

Figure 3. Mean May – October 1m water temperatures for Lake Lucerne

1.2 Nutrient and Chlorophyll Analysis (Lake Lucerne)

TN concentrations began slightly higher in spring and tapered off until in late summer, remaining stable for the rest of the monitoring season. Phosphorus was generally stable at low levels throughout the season with little variability (Figure 4).

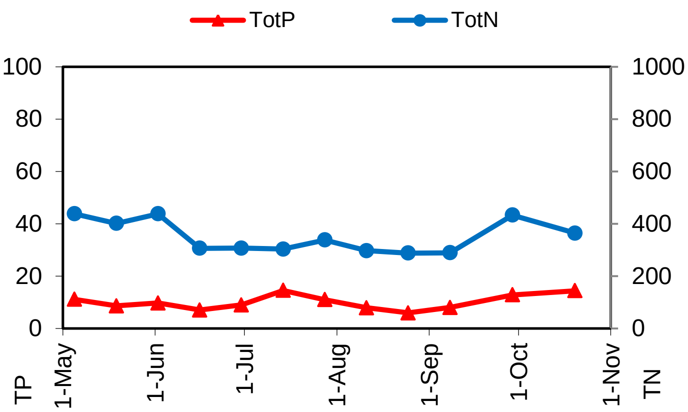

Figure 4. WY 2013 Lake Lucerne Total Phosphorus and Total Nitrogen Concentrations

Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 20.9 to 57.8 with an average of 38.7, which suggests generally poor conditions for the growth of nuisance bluegreen algae at Lake Lucerne (Figure 5). The lowest N/P value was found in July, when an uptick in phosphorus was not matched by an equivalent increase in nitrogen. The last sampling in the year also produced a N/P ratio around the cyanobacterial threshold.

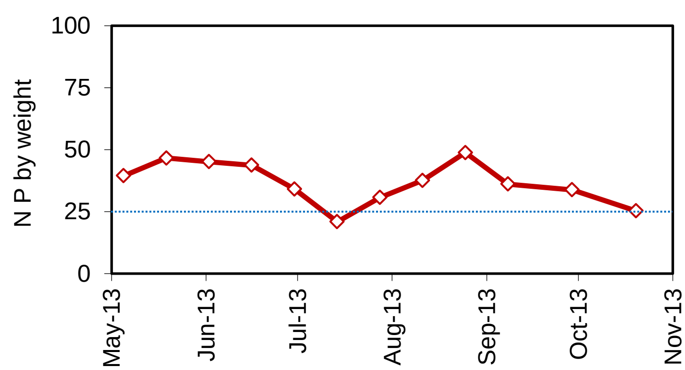

Figure 5. 2013 Lake Lucerne N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria

Chlorophyll *a* concentrations remained low throughout the season (Figure 6), with little change until a rise at the end of September and into October. Pheophytin, which is degraded chlorophyll, was at levels near or below detection levels throughout most of the period, with higher values in May and then again at the end of the season. A somewhat similar pattern was found in adjacent Pipe Lake.

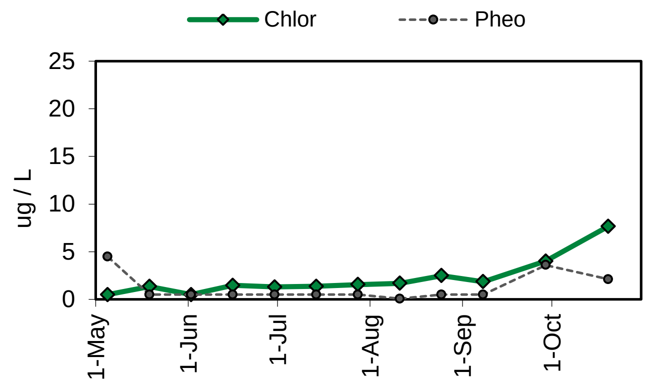

Figure 6. 2013 Lake Lucerne Chlorophyll-*a* and Pheophytin concentrations

1.3 Water column profiles

Profile temperature profile data indicate that thermal stratification was present by mid-May and persisted through the summer (Table 1).

Table 1. 2013 Lake Lucerne profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Lucerne	5/19/13	5.3	1	20.0	1.4	**0.5**	0.401	0.022	0.0086	0.0020	0.0834	29.7
Lucerne			5	12.0	9.1	**0.5**	0.368		0.0106			
Lucerne			9	8.0			0.825	0.506	0.0809	0.0025		
Lucerne	8/25/13	6.0	1	24.0	2.5	**0.5**	0.288	0.007	0.0059	**0.0010**	0.069	32.3
Lucerne			5	22.0	5.9	**2.61**	0.277		0.0072			
Lucerne			9	10.0			1.430	0.447	0.0836	**0.0013**		

Concentrations of total phosphorus (Total P) in the deep water were approximately 10 times higher than in the surface water, which had not changed substantially by late August. The amount of orthophosphate (OPO4) did not follow the same pattern, indicating little release of phosphorus from the sediments back into the lake water, which is an indicator of internal loading. However, an increase in ammonia was found in the deep water on both dates, suggesting the deep water was significantly lower in oxygen content than the 1m water.

Chlorophyll *a* data (Chlor-a) indicate that algae were more abundant in the mid water column on both dates, but with degraded chlorophyll (pheophytin) present in measurable amounts only in August at the mid depth. The Secchi transparency is consistent throughout this period and relates to the low chlorophyll values in the surface water.

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was moderately low, meaning the lake remains somewhat sensitive to acidification. The water color (UV254) was very low, indicating that dissolved organic carbon was not abundant in the lake water.

1.4 TSI Ratings (Lake Lucerne)

The 2013 TSI value for Secchi was on the threshold between oligotrophy and mesotrophy, while the TSI values for chlorophyll and total phosphorus were significantly lower (Figure 7). The average of the three values was 36.5; putting Lake Lucerne in the mid-range of oligotrophy, thus indicating it was low in primary productivity. The relationship between Secchi and total phosphorus indicators have held relatively steady for the past 8 years, with phosphorus predicting less productivity than the Secchi values. The chlorophyll TSI has been more variable between years, but has generally been between the other two values. However, all are in the same general level of algal productivity at or below the mesotrophic threshold.

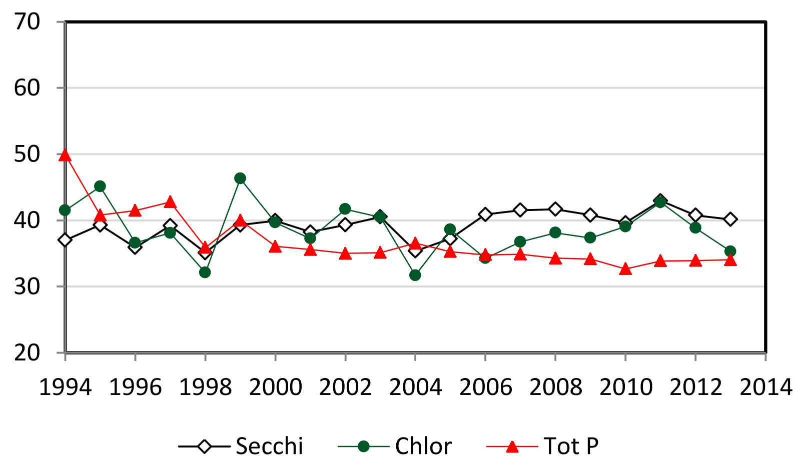

Figure 7. Lake Lucerne Trophic State Indicators

A trend line run through the TSI-TP indicator values since 1998 shows a significant decreasing trend over time (Figure 8). The correlation coefficient of 0.554 indicates that 55% of the variability in the data can be explained by a downward trend over time. This suggests that the large stormwater pond in the Brown Plat development brought on-line in

2008 has been sufficient to-date in preventing an increase in phosphorus from entering Lake Lucerne due to the construction and occupation of new residences in the watershed.

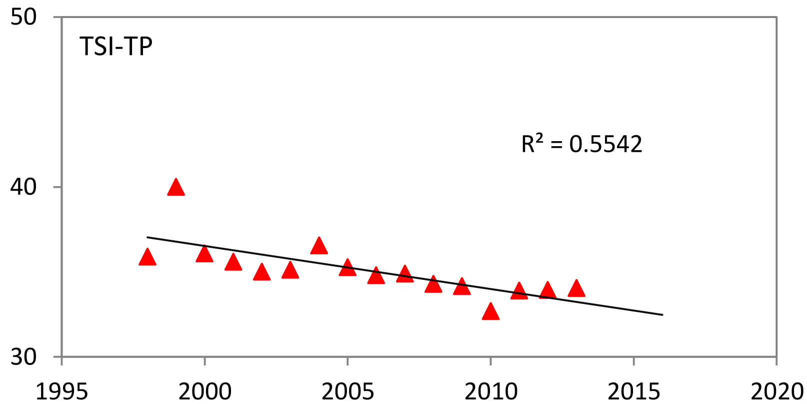

Figure 8. Lake Lucerne TSI-TP trend since 1998

1.5 Conclusions and Recommendations

Based on monitoring data, overall water quality in Lake Lucerne appears to have been stable over the period measured. Generally high N:P ratios indicate conditions are not favorable for nuisance bluegreen algae blooms most of the time.

Residential development continues in the Lake Lucerne watershed, and continuing to monitor the lake will insure that impacts from stormwater will be noticed if they begin to have negative effects on the water quality of the lake.

With the sunset of herbicide treatments as part of the hydrilla eradication project in both Pipe and Lucerne Lakes, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants colonizing the lake, such as Eurasian watermilfoil, in addition to the return of native aquatic plants.

2.0. PIPE LAKE

Volunteer monitoring began at Pipe Lake in the 1970s and has been continuous since the early 1990s. The data indicate this 52-acre lake is low in primary productivity (high oligotrophic) with very good water quality. Approximately 55% of the shoreline of Pipe Lake is in the City of Maple Valley. The remainder is in the City of Covington.

Pipe Lake has no public access boat launch, but there is a community boat launch at Cherokee Bay. The lake is connected to Lake Lucerne by a short, shallow channel and has a history of both milfoil and hydrilla infestations for which eradication efforts have been funded by government agencies since 1995. Eurasian watermilfoil has been eradicated, and the last plant of hydrilla was found in 2006. The year 2013 is the fourth one in which no herbicide was applied to the lake. Instead, a diving survey focused on finding any resurgence of hydrilla, as well as documenting the return of native aquatic plants to the lake. Residents should watch aquatic plants growing nearshore to catch growing patches of milfoil, hydrilla or other noxious weeds. To date no hydrilla has been found and no other submerged noxious aquatic weeds have been identified, although native plants are returning and providing good habitat for fish and other wildlife.

2.1 Physical Parameters

No precipitation or lake level data were collected for Pipe Lake in 2013.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season during which volunteers collect water samples for laboratory analysis. Secchi transparency from late May through October ranged from 3.7 to 7.0 m, averaging 5.8 m, which placed it second among the lakes for clarity during 2013 monitoring (Figure 9). This was an increase from 2012 when the average was 4.4 m.

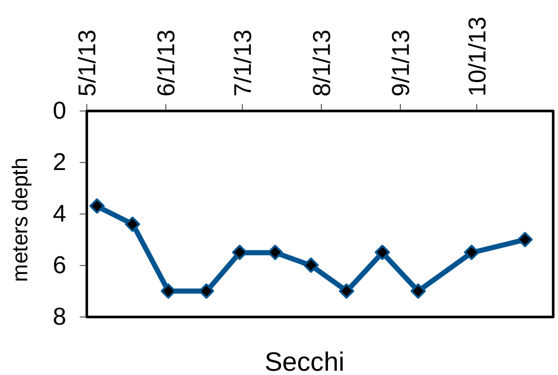

Figure 9. WY 2013 Pipe Lake Secchi Depth. Note inverted Y-axis.

Water temperatures during the same period ranged from 16.5 degrees Celsius to a peak of 24.5 degrees Celsius (Figure 10) with an average of 21.0, which was the warmest average of all lakes monitored in 2013, as well as warmer than the previous year.

The temperature of the shallow water rose steeply in June and remained at a relatively constant level through summer, not decreasing significantly until October.

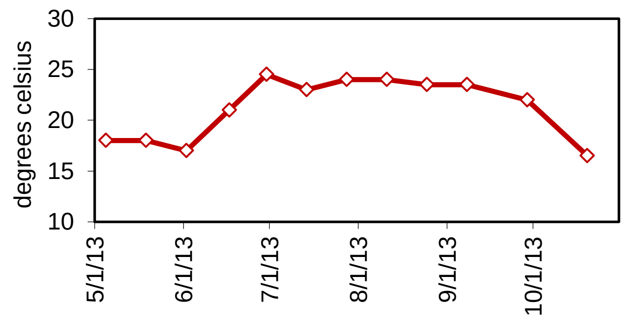

Figure 10. WY 2013 Pipe Lake Temperature at 1 m

Mean summer 1 m water temperatures over the years of monitoring in Pipe Lake have varied between years, particularly during the early years of measurement (Figure 11), and after a period of relative stability between 2006 and 2012, the average increased sharply in 2013, due to the long period of warm surface temperatures shown in Figure 10. However, to-date, the summer average temperature shows no statistically strong trend of change through time. A regression line run through all of the yearly averages is flat, with a low correlation coefficient, indicating that no directional trend can be detected based on the collected data.

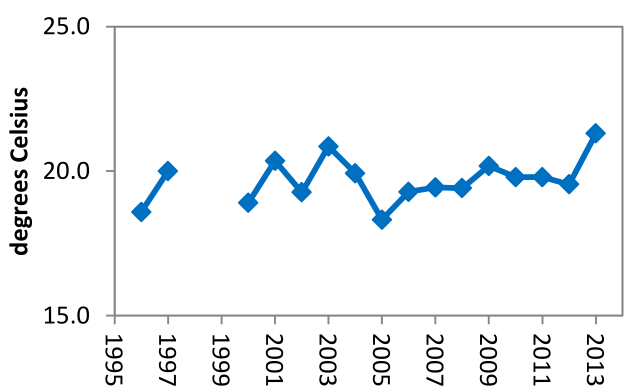

Figure 11. Mean May – October 1m water temperatures for Pipe Lake over time

2.2 Nutrient and Chlorophyll Analysis (Pipe Lake)

Total nitrogen remained relatively stable from May through late October, with very slight increases in the beginning and end of the season (Figure 12). Total phosphorus remained low through the entire season, with a similar pattern and only small variations between dates. Note that on the chart, the TN scale is 10x the value of the TP scale.

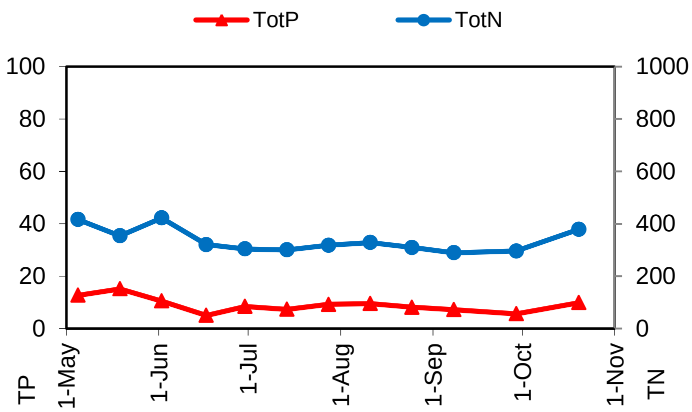

Figure 12. 2013 Pipe Lake Total Phosphorus and Total Nitrogen. Concentrations in ug/L

The N:P ratio ranged from 23.6 to 64.0, averaging 37.6, which is slightly lower than in previous years, but still indicating generally no advantage for nuisance cyanobacterial growth in terms of nutrient ratios (Figure 13). Note that the ratio was at its lowest in late May and was above 25 for the rest of the sampling period. Lakes in the Puget lowlands often support large amounts of cyanobacteria in the fall. However, the overall low values of phosphorus in Pipe Lake would be likely to keep abundance low even if cyanobacteria were present.

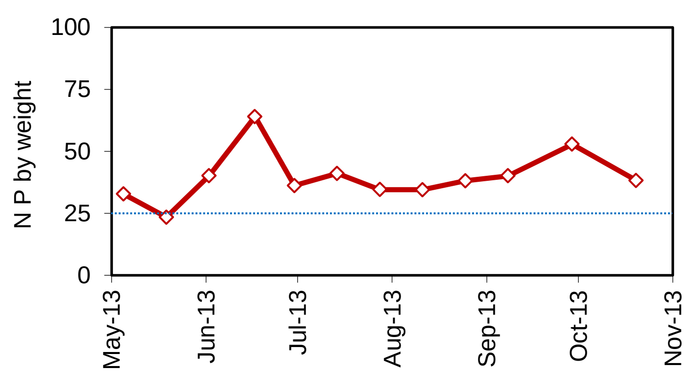

Figure 13. 2013 Pipe Lake N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria

The chlorophyll-*a* level rose a little in late May, but remained very low through the season until it climbed to a maximum in October (Figure 14). Pheophytin, which is a degradation product of chlorophyll, stayed below the minimum detection level until September, when it rose slightly. This indicates that phytoplankton concentrations remained generally low in Pipe Lake throughout the summer, climbing slightly in fall with thermal mixing, which is consistent with phosphorus limitation. This is very similar to what was observed in Lake Lucerne in 2013.

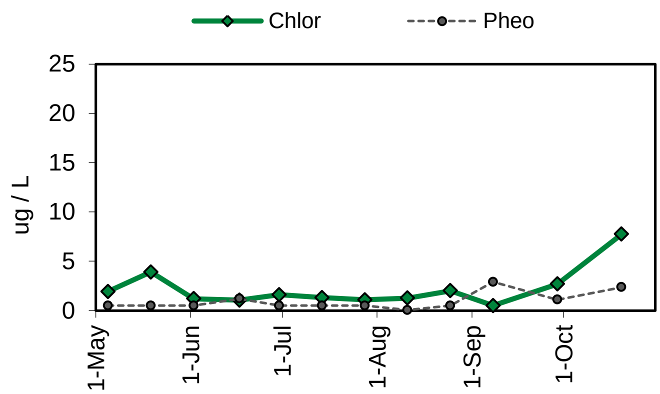

Figure 14. 2013 Pipe Lake Chlorophyll-*a* and Pheophytin concentrations

Profile water temperatures collected in May indicated stratification was present at that time, and it was the same in late August (Table 2).

The May profile showed a small increase in total phosphorus, orthophosphate (OPO4), and ammonia (NH3) in the bottom water, but all had risen considerably by August. This indicates that low oxygen conditions were established in the bottom water of Pipe Lake by late summer, resulting in some phosphorus release from the sediments that can contribute to internal loading.

Chlorophyll-*a* data indicated that shallow water algae were approximately equivalent in May and August, with more present in the middle depth than at the surface on both occasions. The small amounts of chlorophyll correlated with the high Secchi readings that indicate very clear water.

Table 2. 2013 Pipe Lake profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Pipe	5/19/13	7.0	1	17.5	2.0	**0.5**	0.386	0.021	0.0064	**0.0020**	0.0827	29.1
Pipe			10	5.5	2.4	**17.4**	0.449		0.0088			
Pipe			19	5.0			0.656	0.037	0.0524	0.0043		
Pipe	8/25/13	5.5	1	23.5	2.0	**0.5**	0.309	0.005	0.0081	**0.0010**	0.065	30.0
Pipe			10	12.5	3.3	**1.8**	0.414		0.0081			
Pipe			19	4.5			1.590	1.340	0.4110	0.0377		

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low and very similar to adjoining Lake Lucerne, indicating that the lake is somewhat sensitive to pH changes. Water color measurements (UV254) also were very low, contributing to water clarity and indicating that dissolved organic carbon was not an important component of the lake water.

2.3 TSI Ratings (Pipe Lake)

The 2013 TSI indicators for chlorophyll *a* and total phosphorus were very close to each other in the oligotrophic range. The TSI–Secchi indicator was just below the mesotrophic threshold (Figure 15). Pipe Lake has been solidly in the range for oligotrophy for some time, and it appears to have been stable since 2001, with minor variations from year to year.

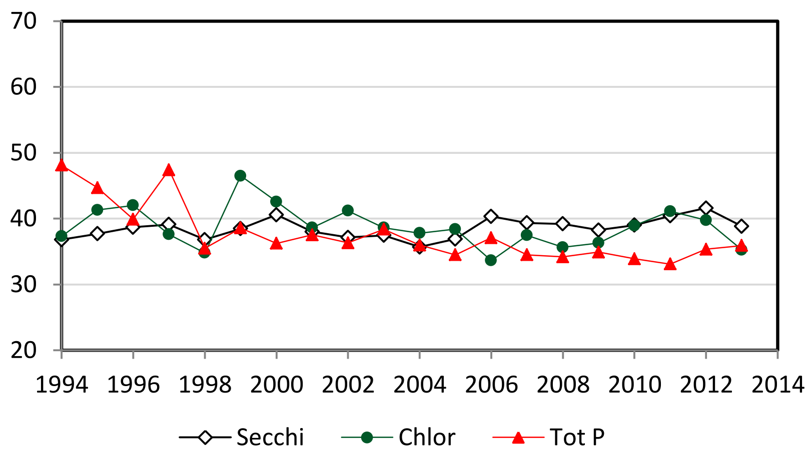

Figure 15. Pipe Lake Trophic State Indicators over time

A trend line run through the TSI-TP indicator values since 1998 shows a decreasing trend over time (Figure 16). A correlation coefficient ($R^{2)}$ of 0.362 indicates that 36% of the variability over time can be explained by the trend. This is similar to the decreasing trend observed in Lake Lucerne, although it is not as strong of a correlation. However, it does support the idea that stormwater controls connected to residential development in the area have been successful to-date in preventing an increase in nutrient delivery to these two lakes.

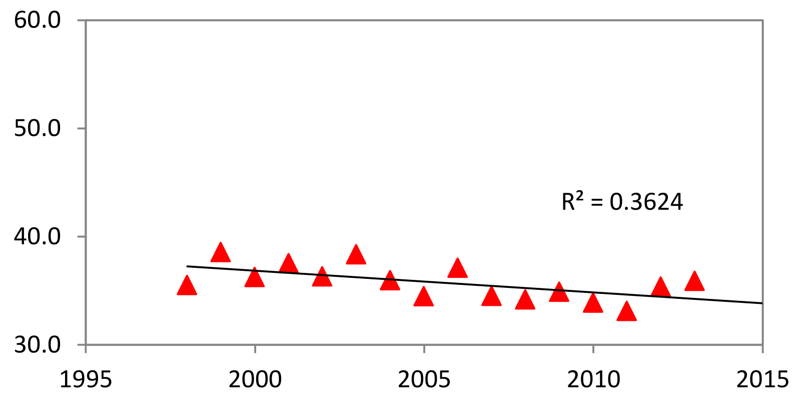

Figure 16. Pipe Lake TSI-TP trend since 1998

2.4 Conclusions and Recommendations

Based on monitoring data, water quality in Pipe Lake appears to have been stable over the last decade or even longer, although measurements were more variable in the early years of the monitoring. The N:P ratios indicate conditions in the lake are not generally favorable for nuisance bluegreen algae blooms. To-date, the data suggest that recent residential construction in the watershed has not increased algal nutrient inputs that could impair water quality.

With the sunset of the hydrilla eradication project in the lakes, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants, such as Eurasian watermilfoil and Hydrilla, as the aquatic vegetation returns to the lake.

3.0. LAKE WILDERNESS

Volunteer monitoring began at Lake Wilderness in the mid-1970s and has continued through 2013, with few gaps in the record. The data indicate this 67-acre lake is moderate in primary productivity (mesotrophic) with generally good water quality.

Of the three lakes in Maple Valley, Wilderness is the only one that has an active “Level I” volunteer, whose monitoring consists of daily precipitation and water level readings, as well as weekly measurements of water temperature and clarity throughout the entire water year.

Lake Wilderness has a public access boat launch and a large city park with a bathing beach, as well as a regional public trail that occupies much of the east shoreline. There is a history of Eurasian watermilfoil infestation, with control activities funded by the City of Maple Valley and monitored with the help of the community. Residents have been active stewards of the lake through the years and should continue to watch for new patches of Eurasian milfoil, as well as other noxious weeds that might invade the lake, such as Brazilian elodea.

3.1 Physical Parameters

Excellent records of precipitation and water level were kept over the year (Figure 17). The lake level, which generally follows a regional pattern of winter high – summer low stands, increased in early winter and then began to decrease by late April. While there was a steady decrease in the lake level through the summer, overall it was fairly steady throughout the year, unlike some years in the past when large swings in lake level have been observed. There was a difference of only 37 cm between the highest and lowest daily stands during the year, distinctly less than the difference recorded for many previous years.

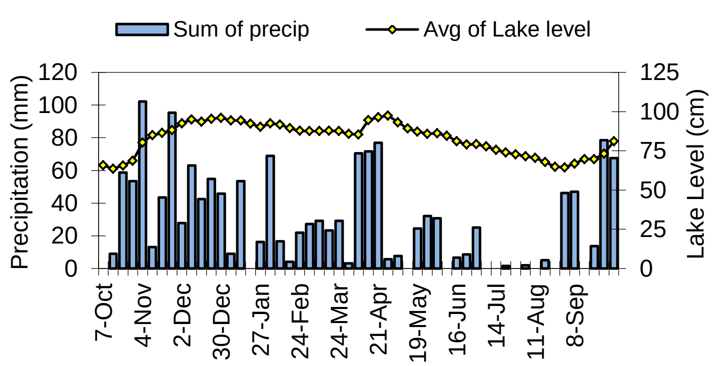

Figure 17. Lake Wilderness Water Year 2013 weekly water levels and precipitation

Secchi transparency ranged from 1.1 to 7.0 m through the year (Figure 18). The summer average of 5.1 m placed it in the upper third for clarity among the monitored small lakes in 2013.

Water clarity fluctuated periodically throughout the season. The low January readings were during a time when a large *Aphanizomenon* bloom turned the lake a bright green color. Summer conditions appeared to be very clear in 2013 and while there were several occasions when clumps of cyanobacteria were reported at the swimming beach, no large blooms were recorded after the winter bloom dissipated.

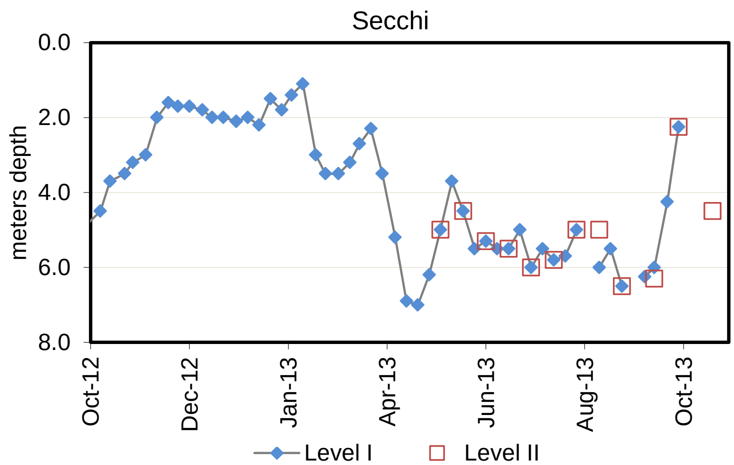

Figure 18. Lake Wilderness Water Year 2013 Secchi transparency. Note inverted Y-axis.

Annual water temperatures ranged from 3.5 to 24.0 degrees Celsius (Figure 19), with a summer average of 19.9 degrees Celsius, placing Lake Wilderness in the middle of the 12 lakes monitored between May and October in 2013.

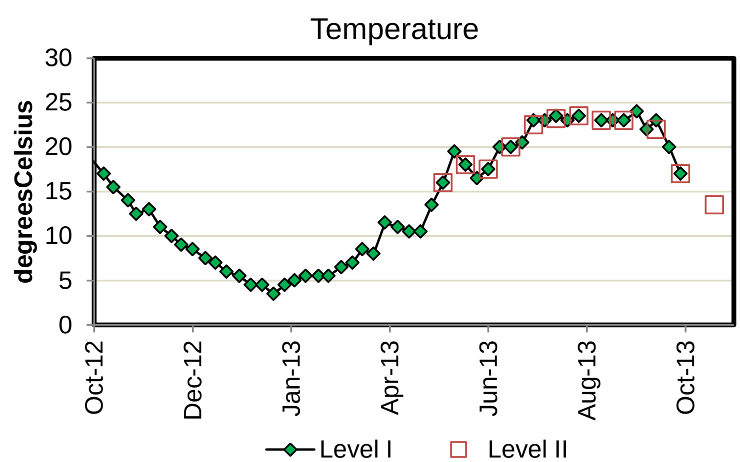

Figure 19. Lake Wilderness Water Year 2013 1m Temperature

Mean summer water temperatures over the years that Lake Wilderness has been monitored have varied between years (Figure 20), but to-date show no statistically strong trend toward change through time. A trend line run through the data is flat with a very low correlation coefficient, suggesting variation without a directional change through time.

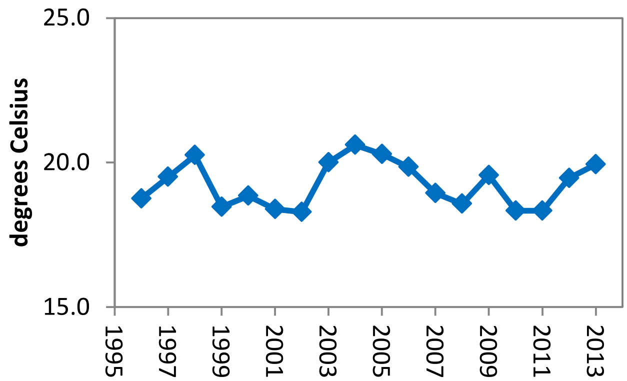

Figure 20. Mean May – October 1m water temperatures in Lake Wilderness

3.2 Nutrients and Chlorophyll (Lake Wilderness)

Total nitrogen started high and decreased from May through August, after which it began increasing rising slowly through October (Figure 21). Total phosphorus dropped after the first sample date and remained low until September when it began to increase concurrently with nitrogen. Note that nitrogen scale is 10x higher than for phosphorus.

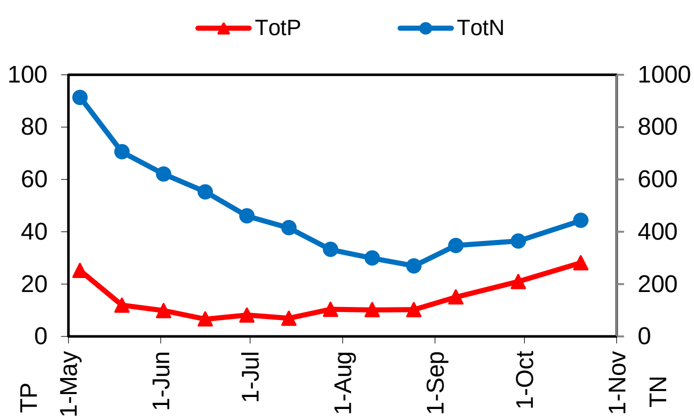

Figure 21. 2013 Lake Wilderness Total Phosphorus and Total Nitrogen in ug/L

The N:P ratio ranged from 15.8 to 83.6, averaging 42.0 over the whole season (Figure 22), but the steady decrease from a maximum in late early July to values below 25 in September show that nutrient conditions became hospitable for cyanobacteria in the fall, similar to previous years. While not as much of a problem as in past years, there were several episodes of cyanobacterial production discussed in a following section.

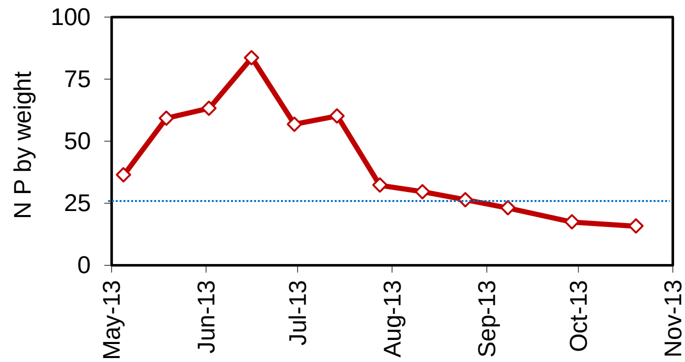

Figure 22. 2013 Lake Wilderness N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria

Chlorophyll-*a* remained low from May until a maximum in September, but declined by the end of the sampling period in October (Figure 23). Pheophytin, which is a degraded chlorophyll molecule, was higher than chlorophyll in late May, but was generally below the minimum detection level until the last sampling date, when it rose slightly.

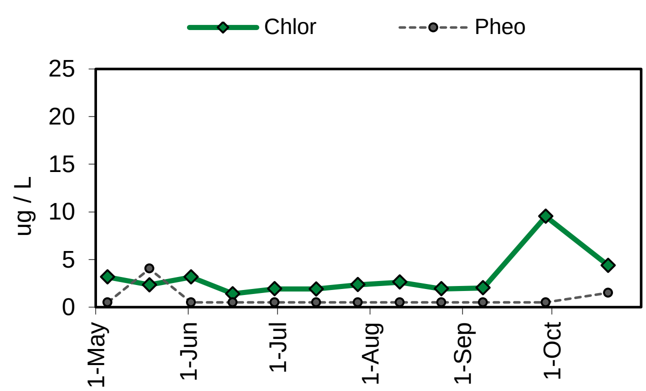

Figure 23. 2013 Lake Wilderness Chlorophyll *a* and Pheophytin concentrations

3.3 Cyanobacteria Toxins

Because of Lake Wilderness has a history of occasional toxin-producing bluegreen (cyanobacteria) blooms, regular surveillance of the lake is carried out by residents, City of Maple Valley staff, and the King County field crew who sample the beach for bacteria during the summer. In winter 2013, a bright green bloom dominated by the cyanobacterium *Aphanizomenon flos-aquae* lasted for weeks and was sampled on a number of occasions, but did not constitute a health or safety risk (Table 3).

Table 3. 2013 Results of cyanotoxin testing at the Lake Wilderness swimming beach. All toxin data in ug/L. <MDL denotes sample was below the minimum detection level for the analysis

Date	Microcystin	Anatoxin-a	Comment
24-Jan-13	0.179	<MDL	Lake was very green
5-Feb-13	0.516	<MDL	Bloom decreasing
18-Mar-13	<MDL		Bloom dissipated
13-May-13	0.16	0.01	
26-Jun-13	21.9	0.295	sampled a dense clump
1-Jul-13	11.7	0.444	sampled a dense clump
1-Jul-13	<MDL	<MDL	water outside of a clump
15-Jul-13	<MDL	<MDL	Clumps dissipated

Clumps of cyanobacteria found along the shoreline in late June (Figure 24) were found to contain microcystin, but away from the clumps the water was free of toxicity. By increasing the warning signage and educating the lifeguards to warn swimmers, the city was able to hold its scheduled annual Fourth of July celebration without health and safety problems.

Figure 24. Cyanobacterial clump near the shoreline at the Lake Wilderness swimming beach

3.4 Water Column Profiles

Profile temperature data (Table 4) indicate that thermal stratification was present early in the season and persisted through the summer, though there was a small temperature increase in the deep water by the end of August.

Table 4. 2013 Lake Wilderness profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Wilderness	5/19/13	4.5	1	18.0	2.3	**4.02**	0.705	0.020	0.0119	**0.0020**	0.0321	42.7
Wilderness			4	14.5	5.9	**1.6**	0.809		0.0284			
Wilderness			8.2	9.0	9.4	**11.2**	0.882	0.211	0.0541	0.0020		
Wilderness	8/25/13	6.5	1	23.0	1.9	**0.5**	0.269	**0.006**	0.0102	**0.0010**	0.032	44.3
Wilderness			4	23.0	1.7	**0.5**	0.268		0.0075			
Wilderness			8	13.0	89.3	20.4	1.120	**0.322**	0.1120	0.0066		

In the May profile event, ammonia and total phosphorus were slightly higher in the deep water sample, which suggests that low oxygen conditions may have started to form. However, the very high total phosphorus and nitrogen values in the deep water in August were not accompanied by a high orthophosphate value, suggesting that the high phosphorus may not have been due to internal loading of phosphorus from the sediments into the lake water. While chlorophyll-*a* was fairly evenly distributed through the water column in May, it was very high in the deeper water in August, accompanied by a significant amount of pheophytin (degraded chlorophyll). This also supports the notion that benthic material was included in the deep water sample, and the organic material from the bottom may also have been the source of the high phosphorus values.

Alkalinity, also known as acid neutralizing capacity, was higher than in nearby Pipe and Lucerne Lakes, suggesting that water coming into the lake in the Wilderness basin contains more dissolved salts that increase the buffering capacity of the lake water.

Water color (UV254) was lower than Pipe and Lucerne, contributing to the exceptional water clarity of Lake Wilderness and indicating that little dissolved organic carbon was coming in from the surrounding watershed. Wilderness had the lowest UV254 measurements of all the lakes monitored in 2013.

3.5 TSI Ratings (Lake Wilderness)

In 2013, the averages for all three TSI calculations were very close together for the first time on the threshold between oligotrophy and mesotrophy (Figure 25). In the past there was a consistent disparity between the TSI-Secchi and the other two indicators (1994 – 2005). This became less clear after 2005, with the TSI-TP frequently more similar to the TSI-Secchi. There appears to be an overall downward trend in the phosphorus TSI (towards less phosphorus in the water), accompanied by an upward trend in the TSI Secchi (towards less clarity).

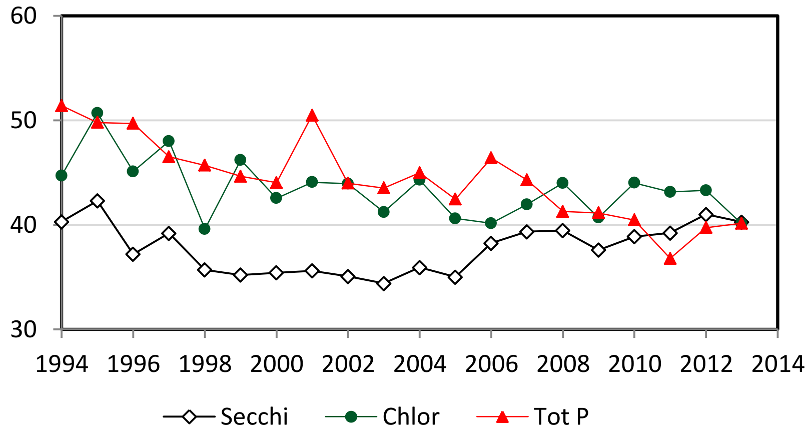

Figure 25. Lake Wilderness Trophic State Indicators over time

The correlation coefficient of regression lines fit through the TSI values (Figure 26) indicate that the decreasing phosphorus trend line is a moderately good fit (r^2 = 0.566), meaning that 56% of the variation is explained by the downward slope. For the Secchi indicator values, 75% of the variability can be explained by an increasing trend slope over time. In contrast, the trend for TSI for chlorophyll is totally flat over the period, and combining the 3 indicators into an average essentially cancels out the two significant trends. One possible ecological explanation for this would be a change in the phytoplankton community from large colonies that make visible particles in the water but do not interfere with clarity readings to smaller forms that make the water cloudy and do interfere with clarity. This could explain the difference in trends for all three indicators, but phytoplankton data are lacking for verification.

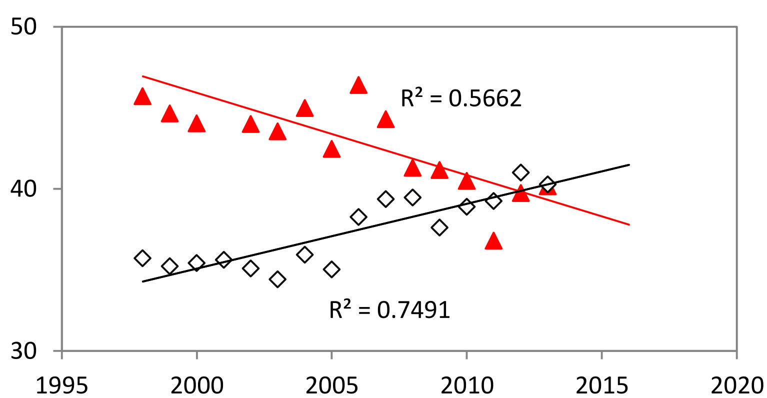

Figure 26. Lake Wilderness trends in TSI phosphorus and Secchi since 1998

3.6 Conclusions and Recommendations

Based on the monitoring data, although overall water quality in Lake Wilderness may be fairly stable over the period measured, there is a downward trend in phosphorus concentrations and an upward trend in TSI-Secchi transparency. This makes it difficult to project into the future, and continued monitoring may be needed to track where the lake may be heading over time. While N:P ratios are very high in spring, they decrease steadily to low values in the late summer and fall that indicate conditions can be favorable for nuisance cyanobacteria.

Two cyanobacterial blooms were sampled in 2013: one in winter and another just before the Independence Day celebration at Lake Wilderness Park. Although the winter bloom turned the lake an intense green color, very little toxicity was detected. In late June, clumps of cyanobacteria produced significant microcystin concentrations, but the clumps were ephemeral and dissipated quickly, while testing of water outside of the clumps indicated that away from the accumulations the lake was safe for recreational activities.

Close monitoring of algae blooms at the lake, particularly during recreational seasons, should continue to determine how frequently the blooms at the lake produce toxins and how often the concentrations are above the draft state guidelines for recreational activities.